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**Mische**

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(54) **PRINTED CIRCUIT BOARD WITH EMBEDDED LATERAL CONNECTOR**

(71) Applicant: **Amazon Technologies, Inc.**, Seattle, WA (US)

(72) Inventor: **William Mische**, Seattle, WA (US)

(73) Assignee: **Amazon Technologies, Inc.**, Seattle, WA (US)

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(Continued)

(52) **U.S. Cl.**

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(Continued)

(58) **Field of Classification Search**

CPC .... H01R 12/721; H01R 12/722; H01R 3/403; H01R 1/184

See application file for complete search history.

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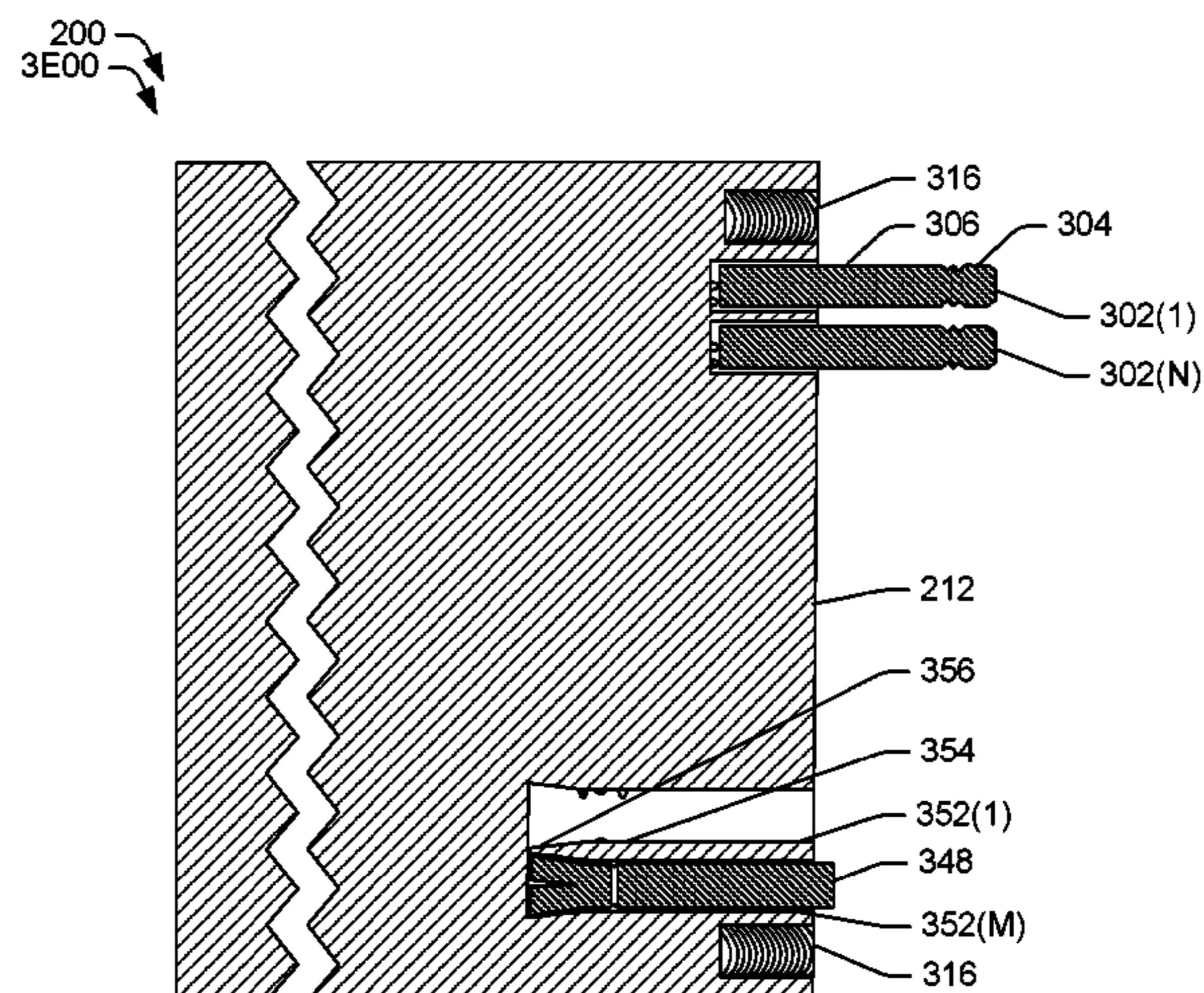
*Primary Examiner* — Tho D Ta

(74) *Attorney, Agent, or Firm* — Lee & Hayes, P.C.

(57) **ABSTRACT**

Printed circuit boards (PCBs) may include embedded lateral connectors. The embedded lateral connectors may be configured to enable components to quickly couple to or plug into a PCB, thus saving time to form connections. The embedded lateral connectors may also reduce weight and/or size by avoiding need for bulky tradition collections with conventional components (e.g., solders, external pin connectors, etc.). The connectors may include male connectors, female connectors, and/or mounting connectors. The connectors may be configured to connect multiple PCBs together, such as using a stacked configuration, which may enable reducing a volume of space needed in a housing for the PCBs.

**20 Claims, 10 Drawing Sheets**



Section A-A

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*H01R 12/73* (2011.01)  
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*H01R 43/00* (2006.01)  
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*H01R 13/52* (2006.01)  
*H05K 3/40* (2006.01)  
*H05K 1/14* (2006.01)  
*H05K 1/18* (2006.01)  
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100

FORM LAYER OF PCB THAT INCLUDES CONNECTOR 102

FORM LAYERS OF PCB TO INCLUDE LATERAL APERTURES FOR CONNECTOR 110

ASSEMBLE PCB 120

CURE PCB 122

A

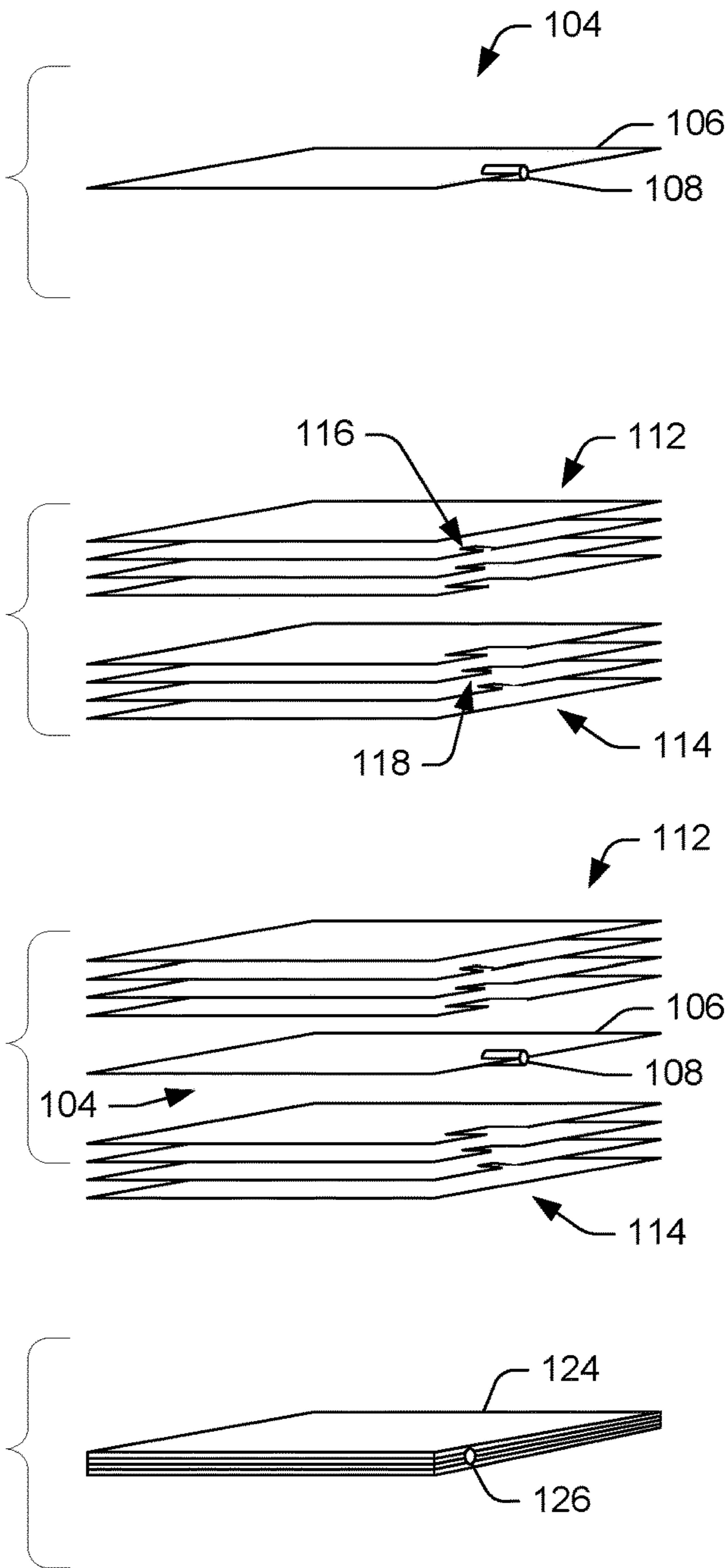


FIG. 1A



128 ↘

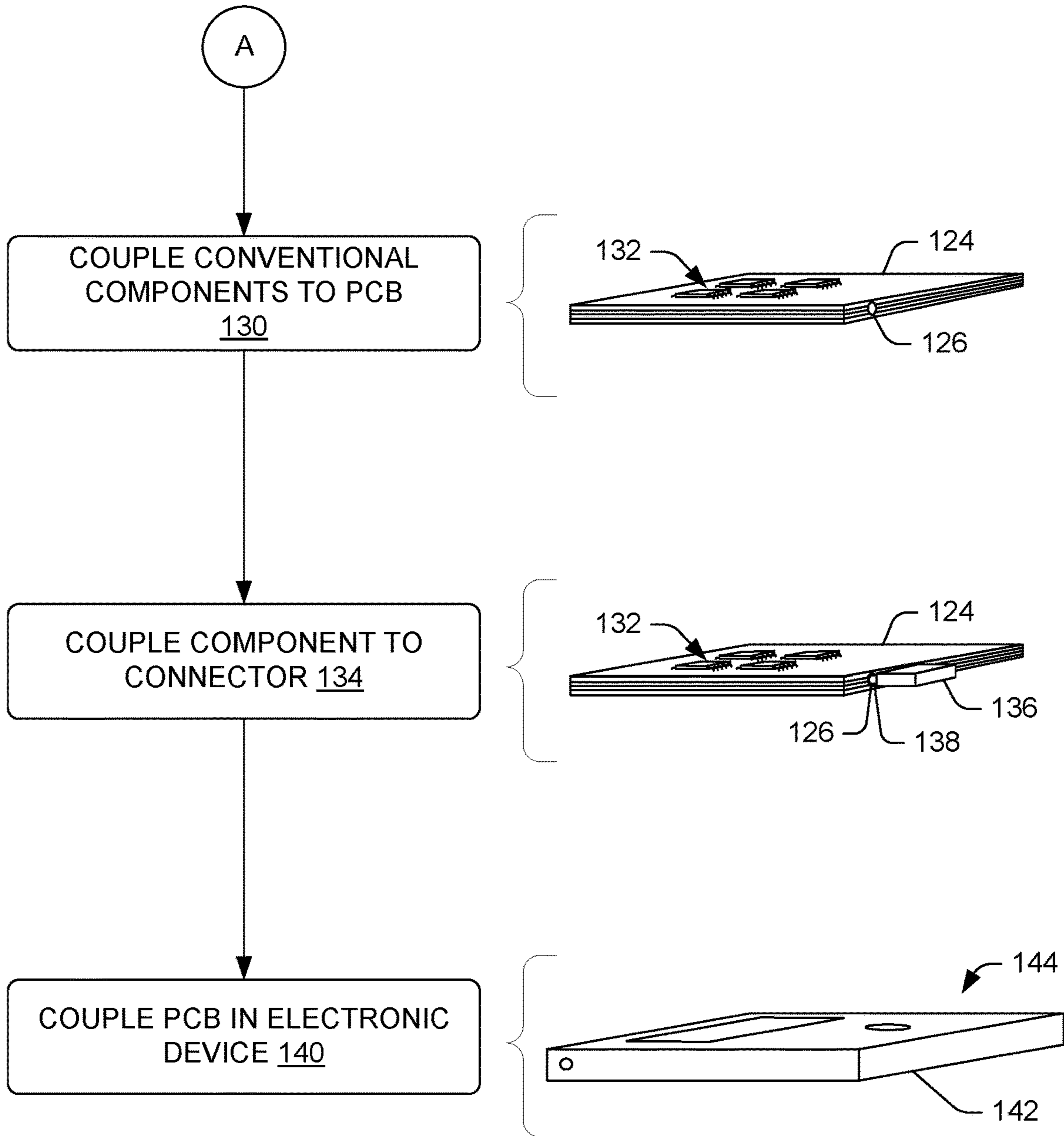


FIG. 1B

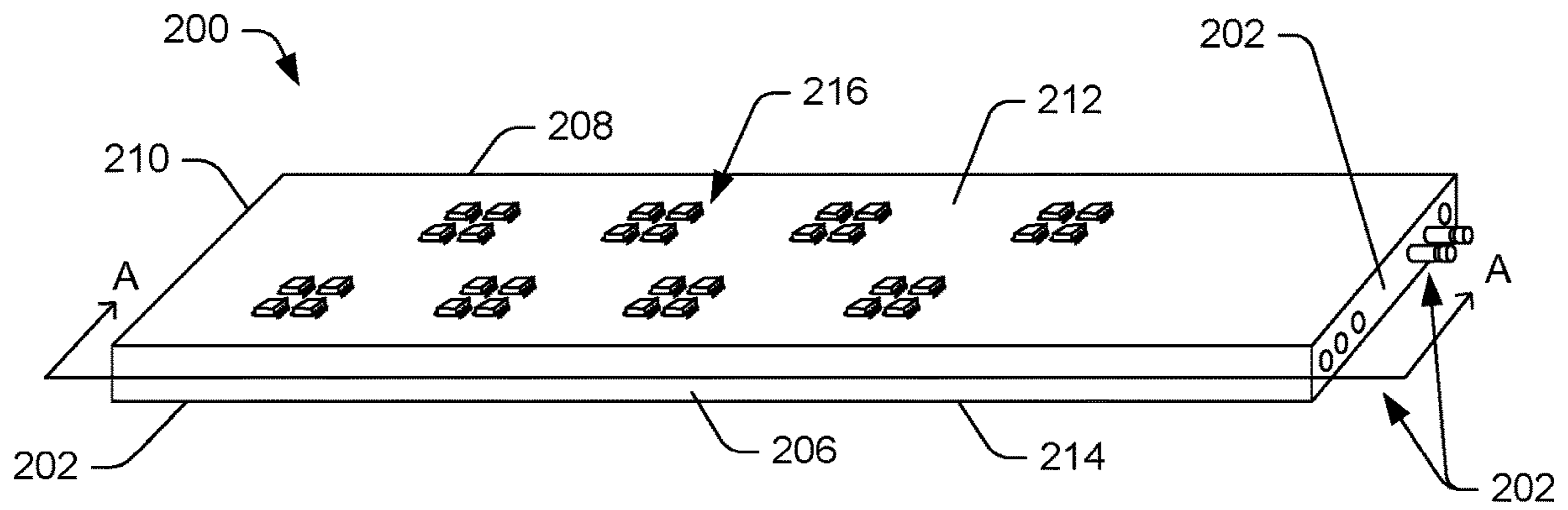


FIG. 2

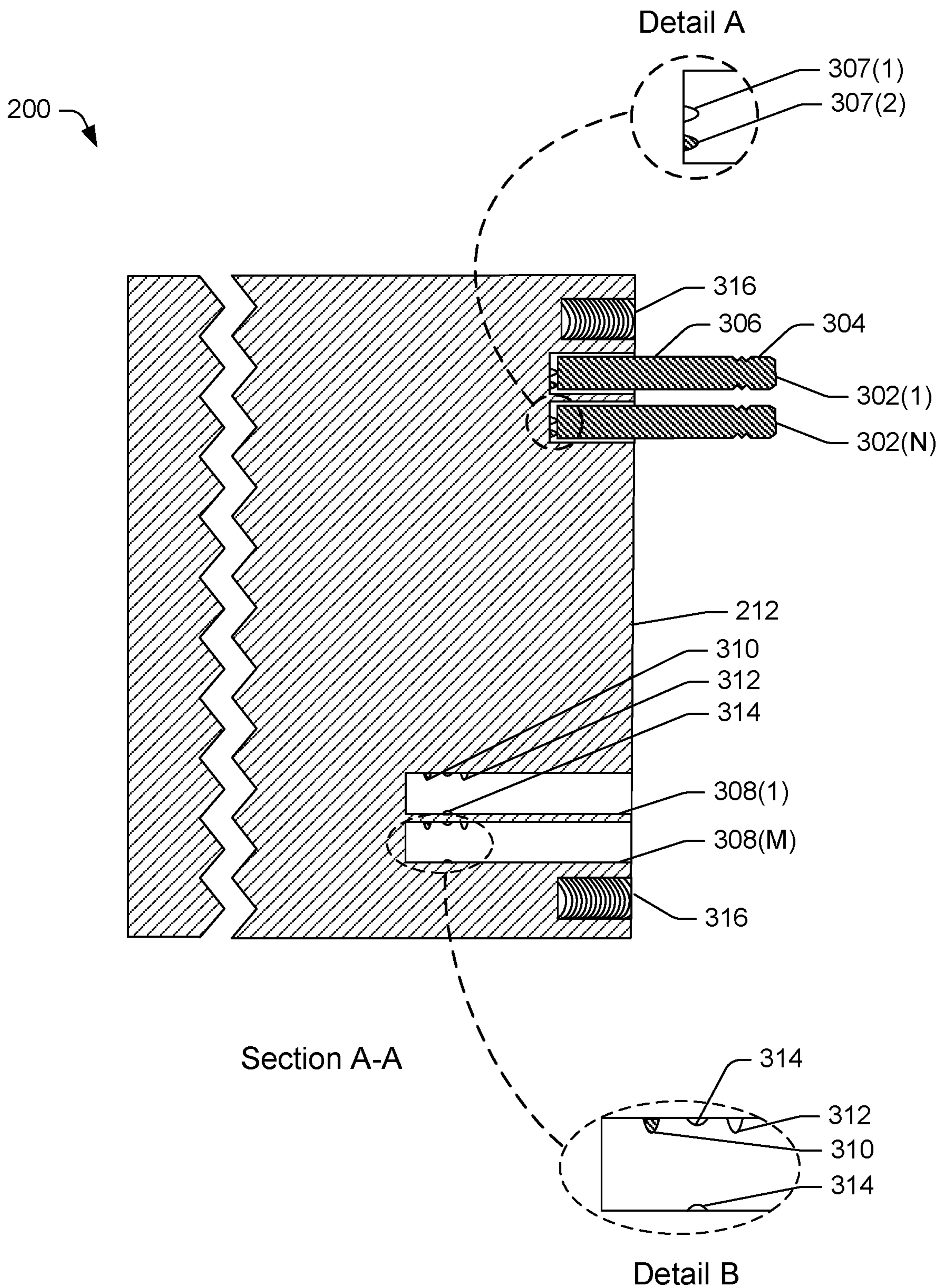
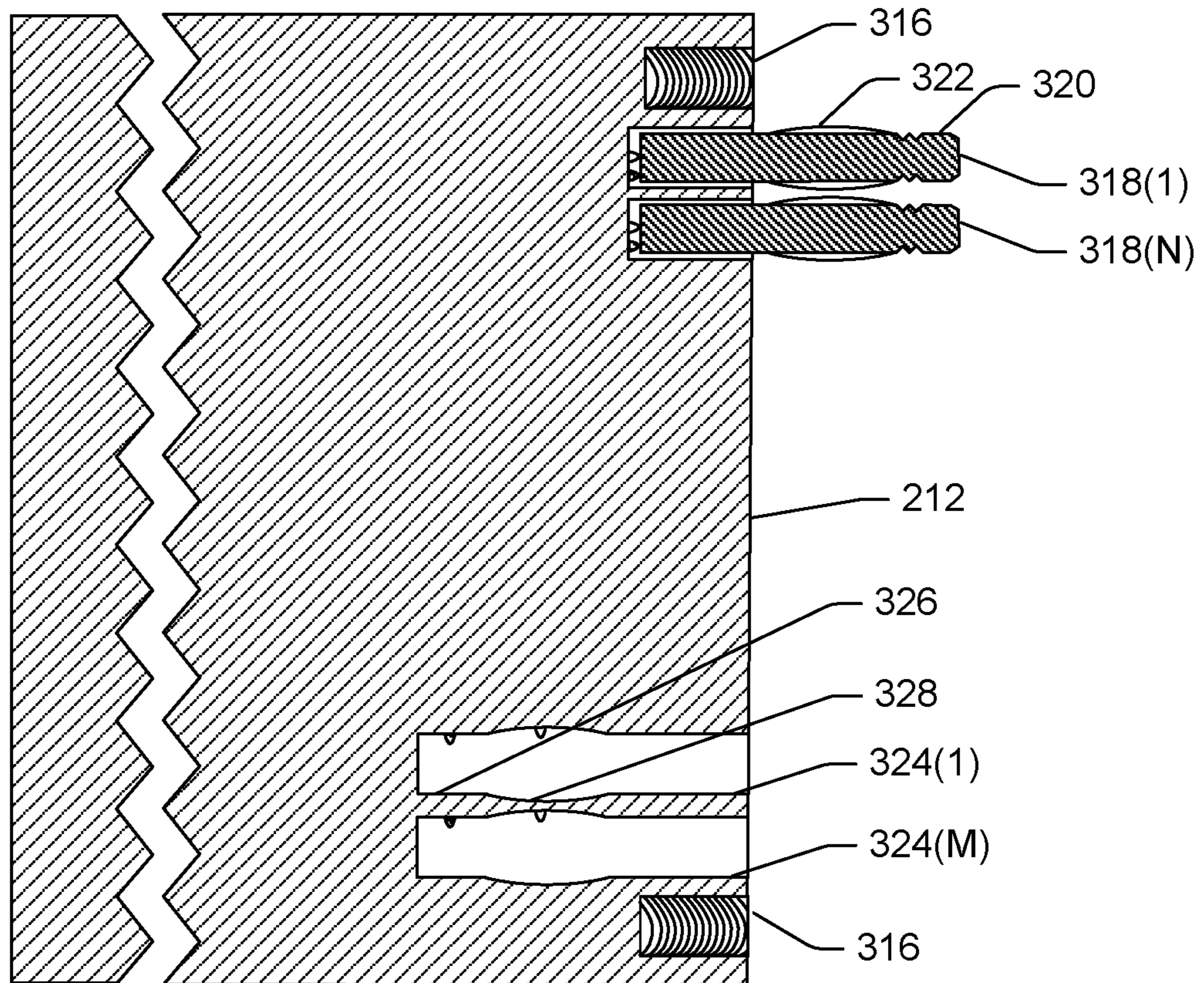


FIG. 3A

200

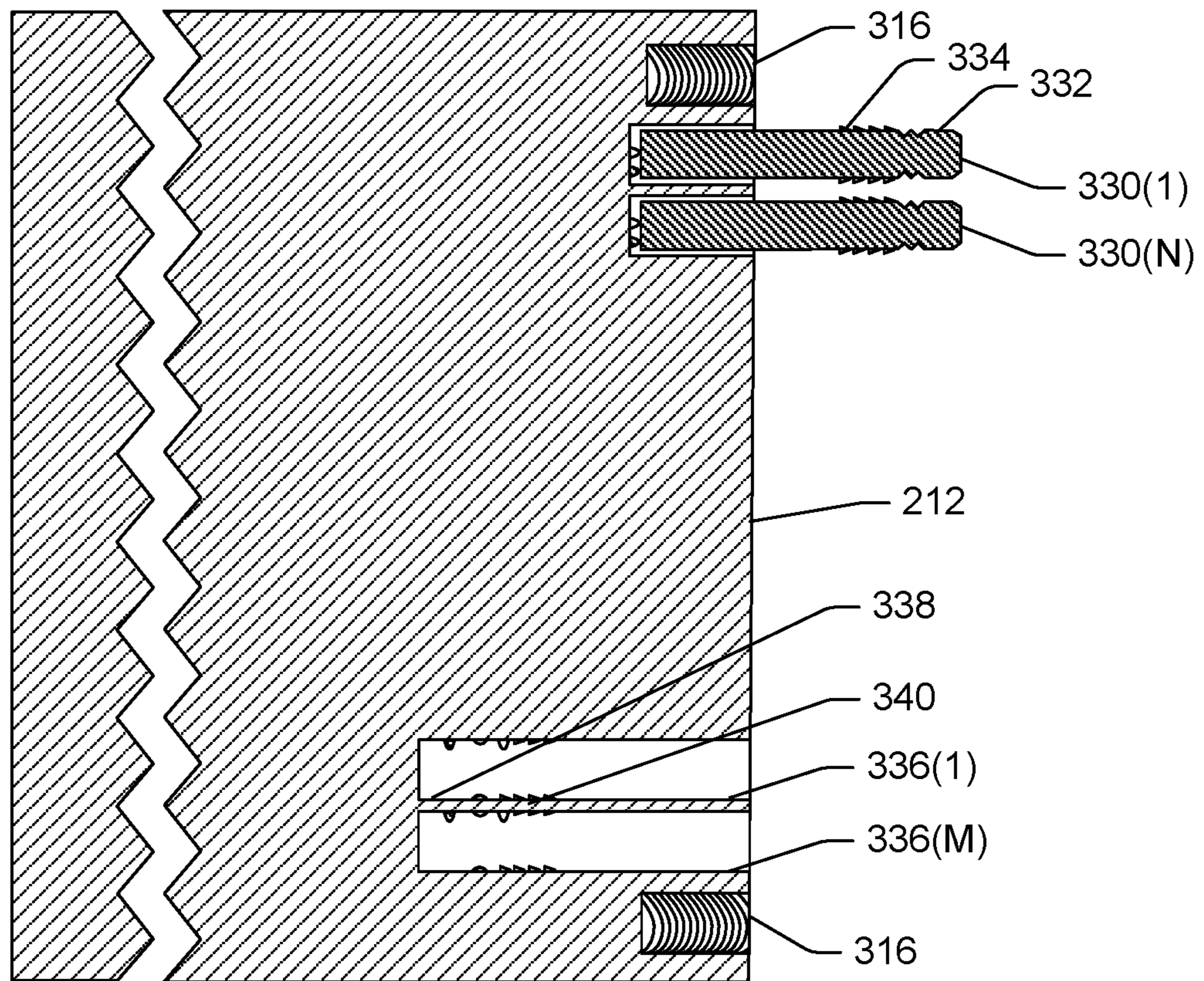


Section A-A

FIG. 3B



200



Section A-A

FIG. 3C



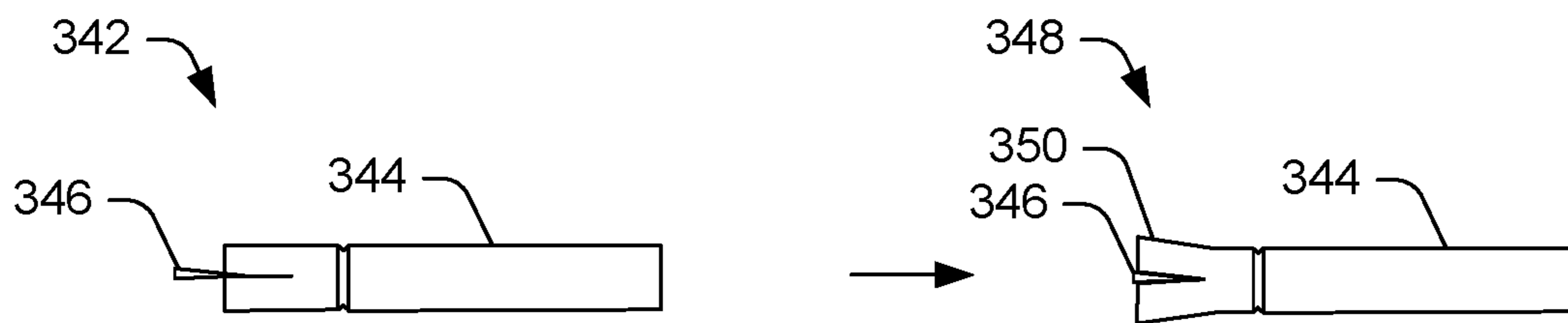
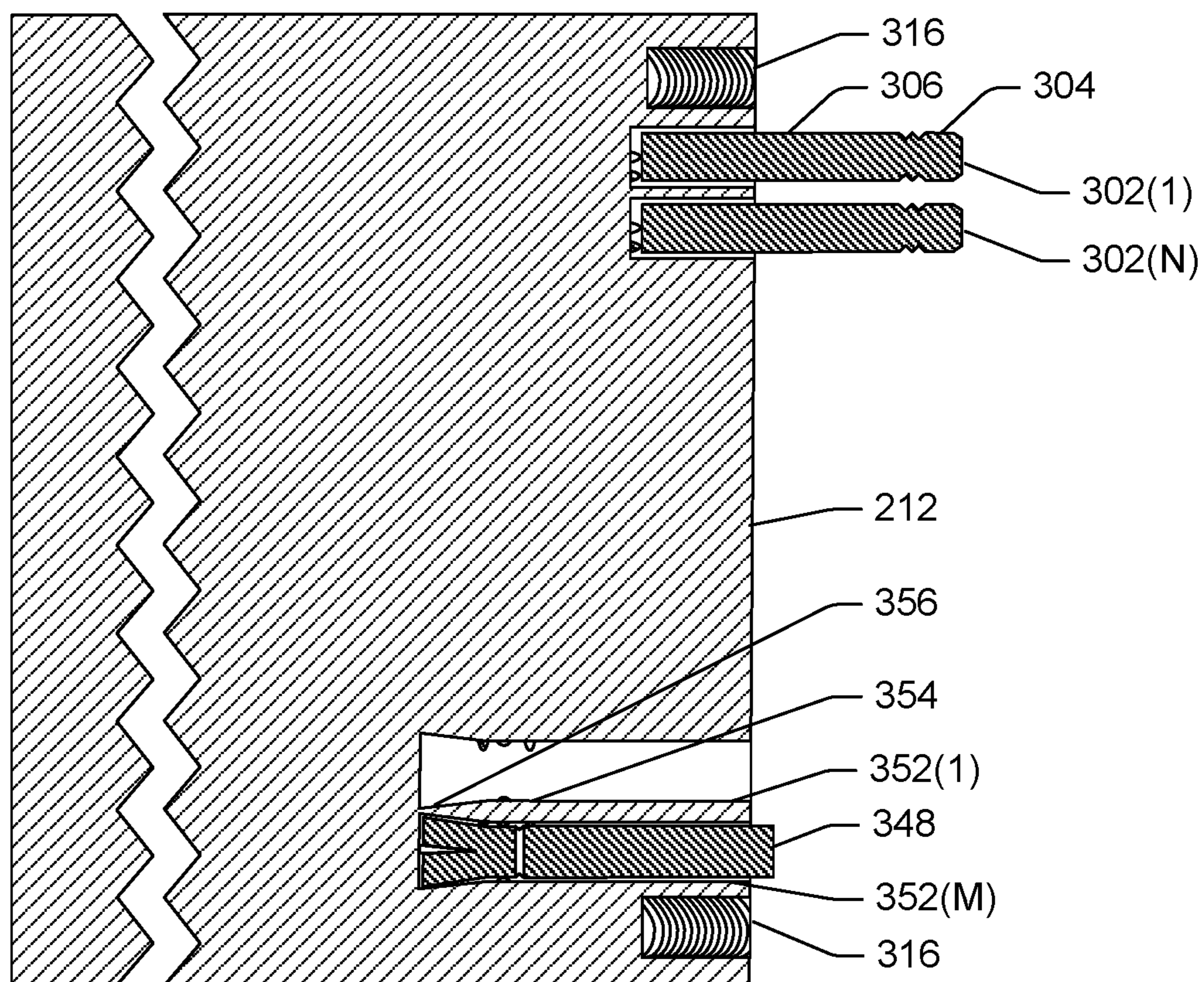


FIG. 3D

200  
3E00



Section A-A

FIG. 3E

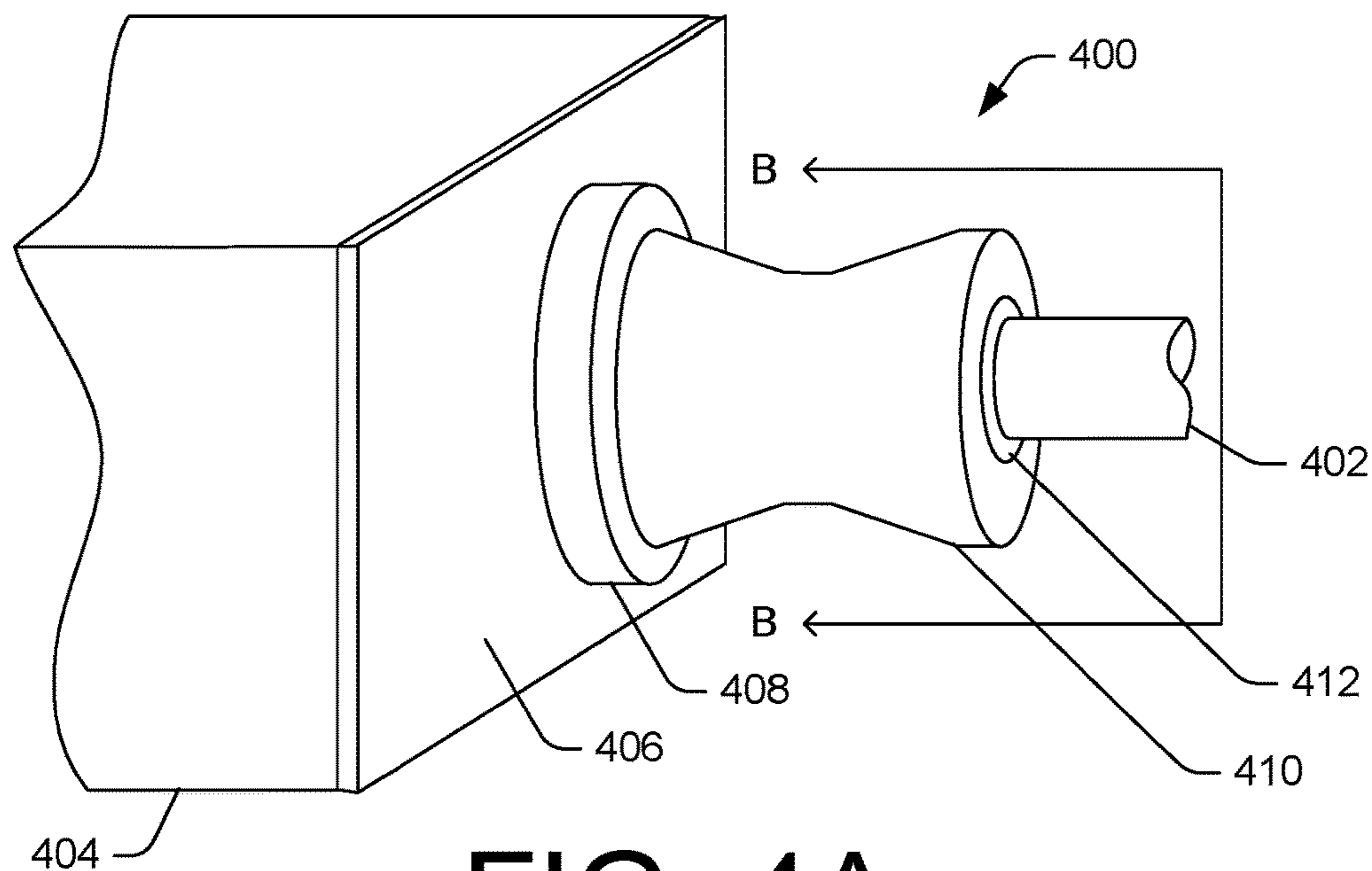
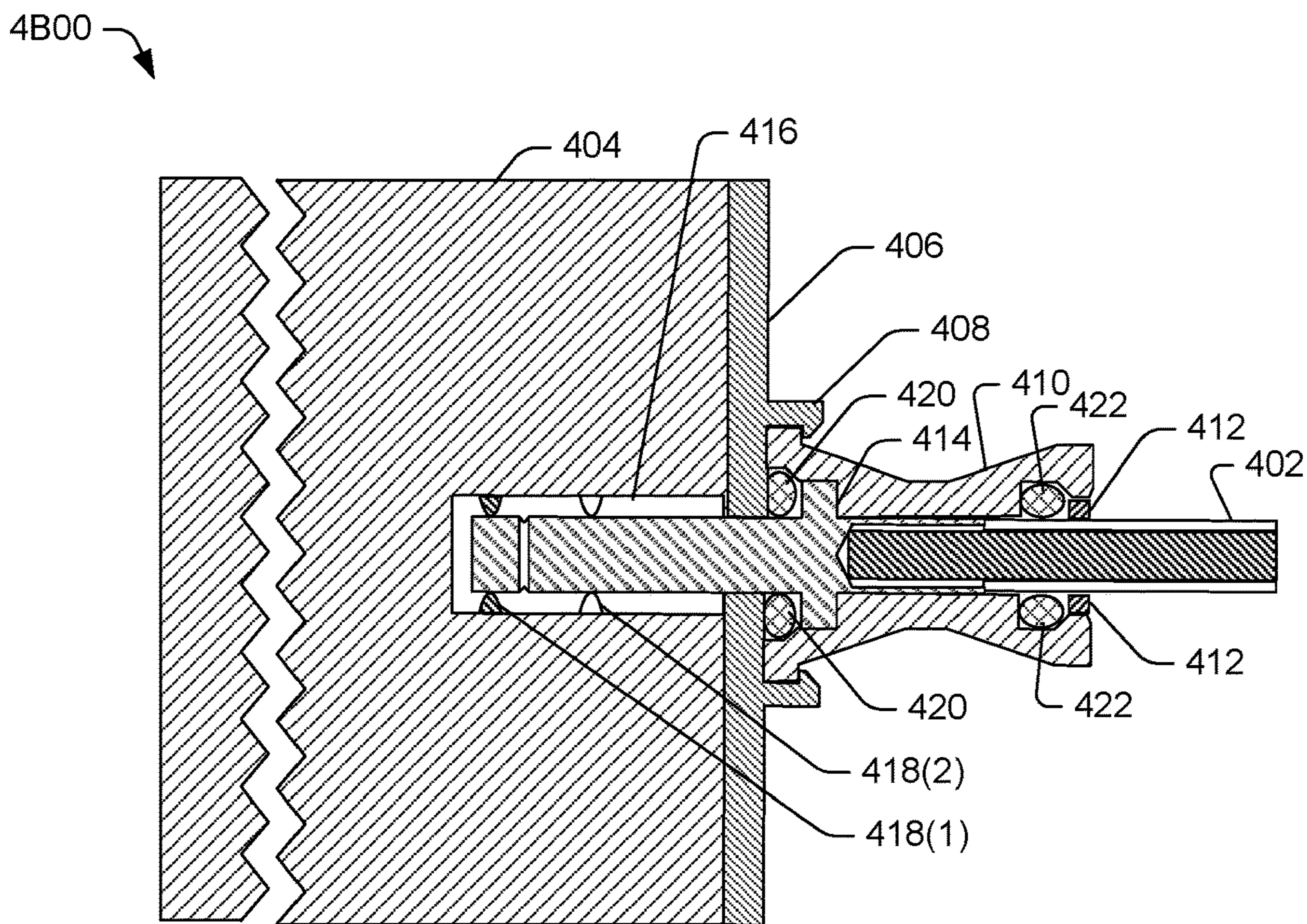


FIG. 4A



Section B-B

FIG. 4B

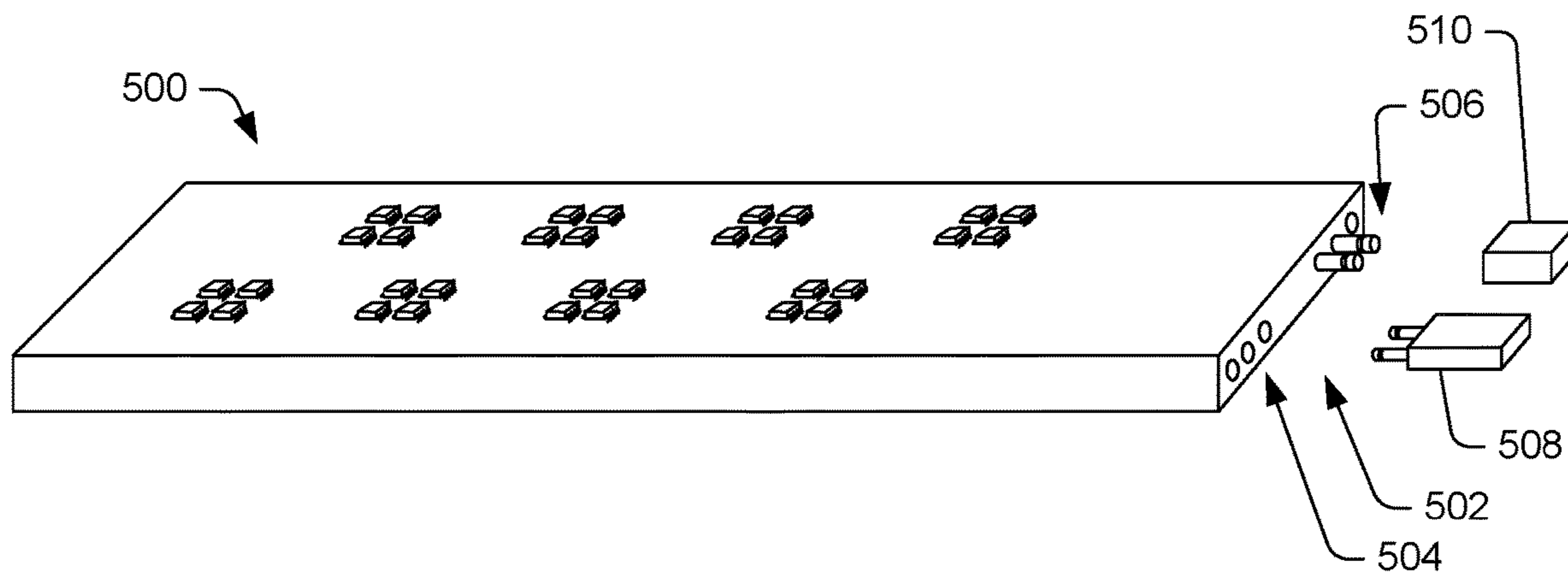


FIG. 5A

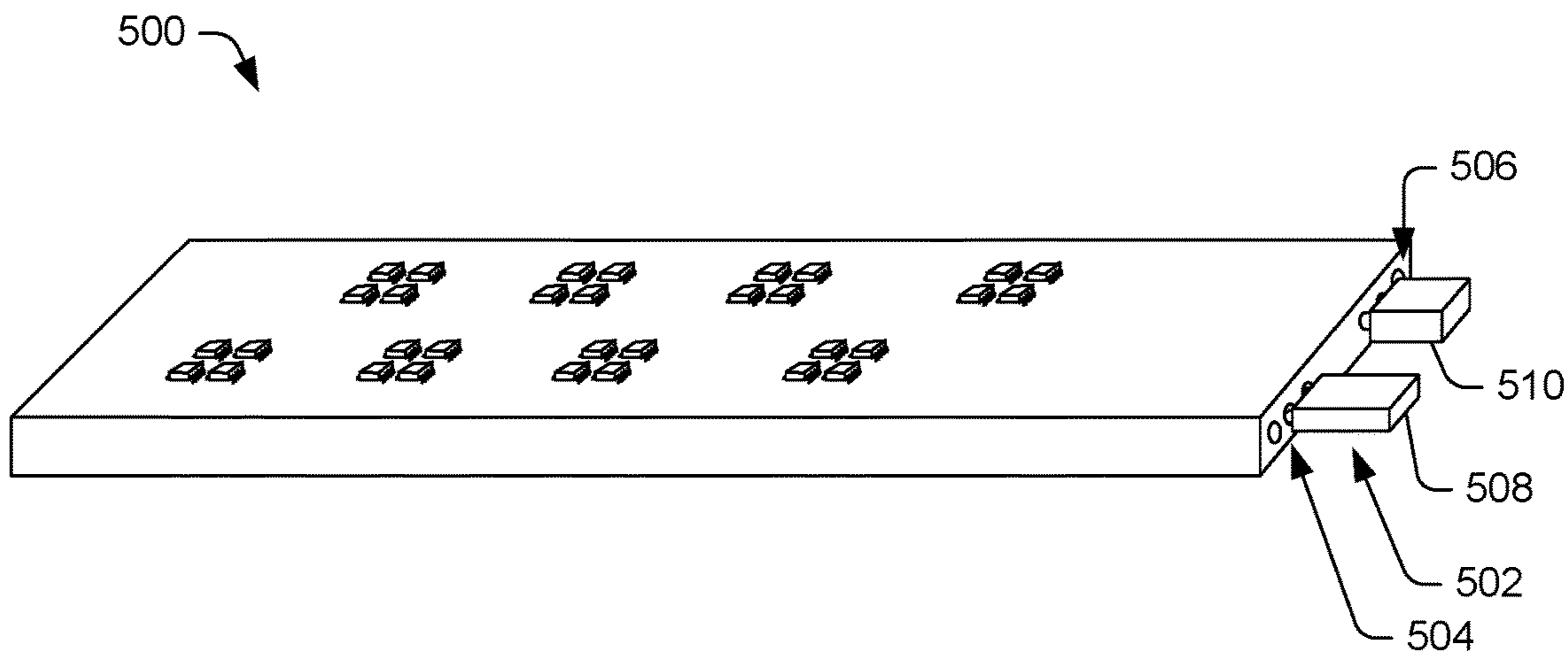


FIG. 5B



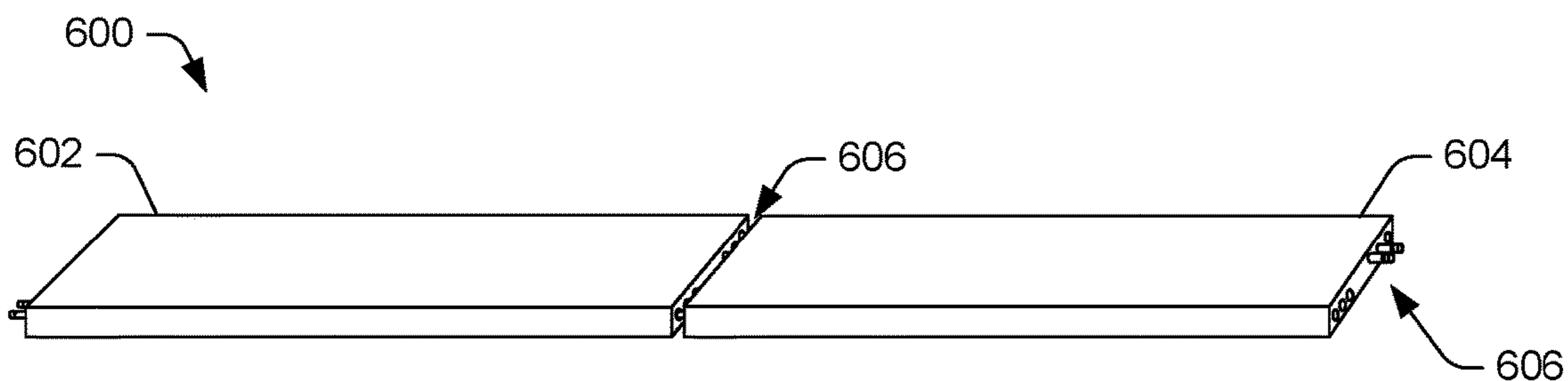


FIG. 6A

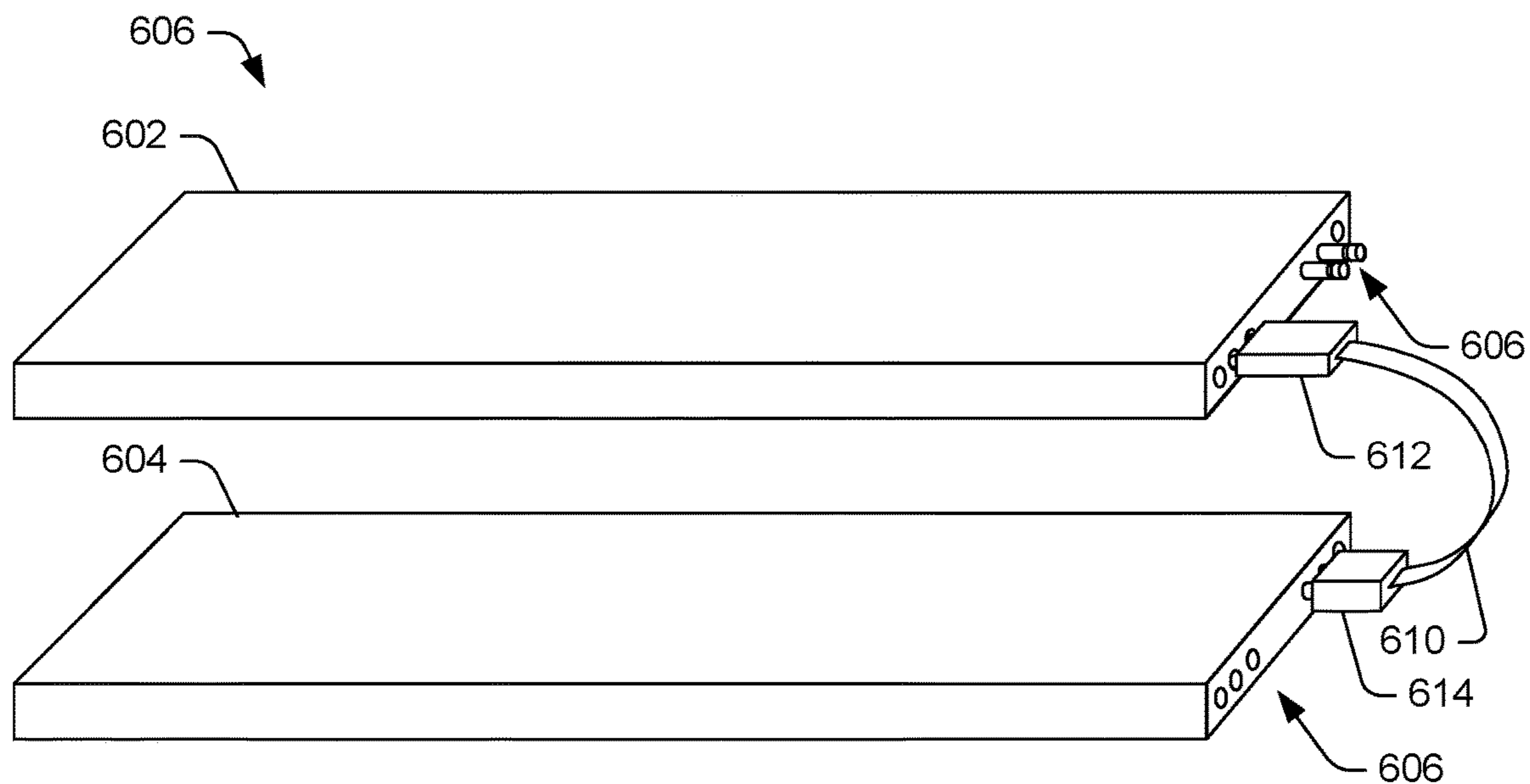


FIG. 6B

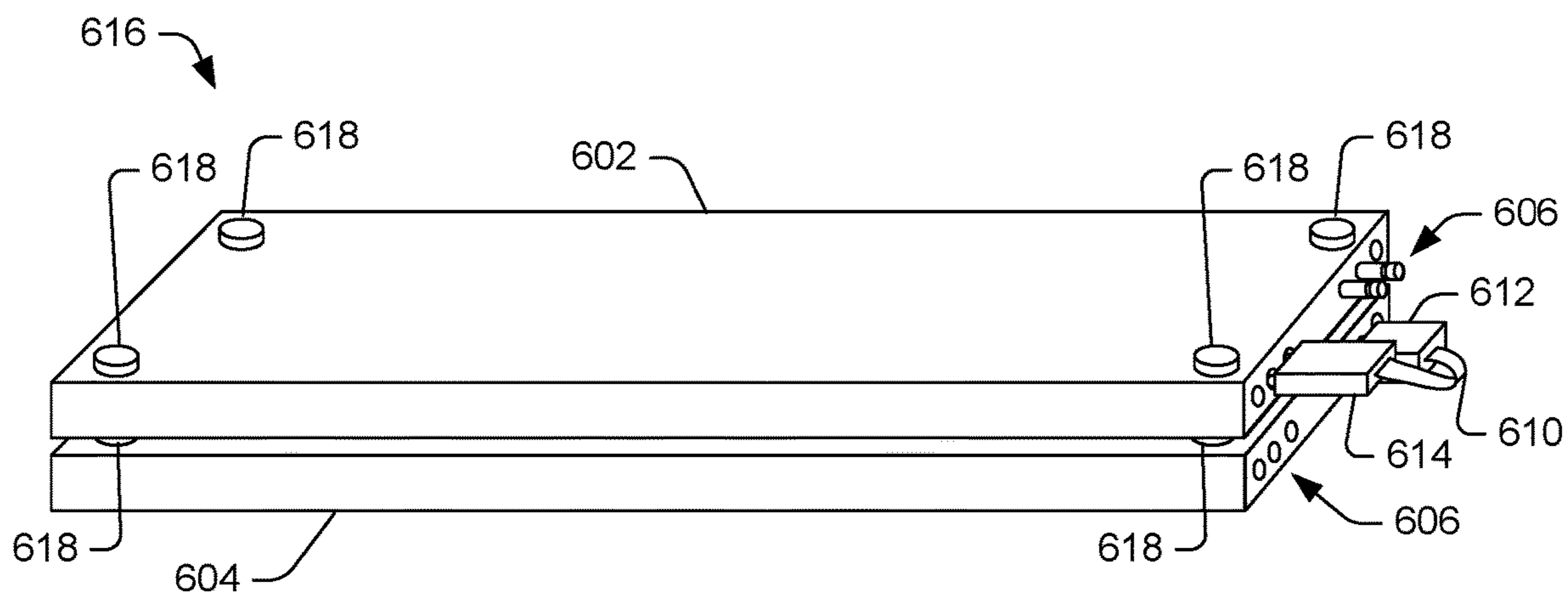


FIG. 6C

## PRINTED CIRCUIT BOARD WITH EMBEDDED LATERAL CONNECTOR

### CROSS REFERENCE TO RELATED APPLICATION

This patent application is a continuation of and claims priority to co-pending and co-owned U.S. patent application Ser. No. 15/812,756, filed Nov. 14, 2017, entitled "PRINTED CIRCUIT BOARD WITH EMBEDDED LATERAL CONNECTOR," which is hereby incorporated in its entirety by reference.

### BACKGROUND

Printed circuit boards (PCBs) are formed during a manufacturing process, and then often later modified to add components, such as surface-mounted processors and other components. Some components are added to PCBs by adding solder to create electrical connections. Other components may be added by bolting through apertures formed through a thin side of a PCB, which is typically less than a few millimeters thick. Both of these processes add weight to the overall system and add bulk by increasing an overall volume of the PCB, and in particular, a thickness of the finished PCB.

### BRIEF DESCRIPTION OF THE DRAWINGS

The detailed description is described with reference to the accompanying figures. In the figures, the left-most digit(s) of a reference number identifies the figure in which the reference number first appears. The same reference numbers in different figures indicate similar or identical items.

FIGS. 1A and 1B show a pictorial flow diagram describing an illustrative process to create an electronic device with a printed circuit board (PCB) that includes an embedded lateral connector.

FIG. 2 is a perspective view of an illustrative PCB that includes an illustrative embedded lateral connector.

FIG. 3A shows a cross-sectional top view of the PCB shown in FIG. 2, showing illustrative details of embedded lateral connectors.

FIG. 3B shows a cross-sectional top view of the PCB shown in FIG. 2, showing illustrative details of embedded lateral connectors having retention features.

FIG. 3C shows a cross-sectional top view of the PCB shown in FIG. 2, showing illustrative details of some embedded lateral connectors having different retention features.

FIG. 3D a schematic diagram of a connector that includes a wedge inserted into a tip of the connector to expand a diameter of the tip to secure the connector in a receptacle.

FIG. 3E shows a cross-sectional top view of the PCB shown in FIG. 2, showing illustrative details of some embedded lateral connectors utilizing a wedge retention feature for use with the connector shown in FIG. 3D.

FIG. 4A is a perspective view of a sealed connector that secures a wire to a PCB.

FIG. 4B is a cross-sectional side elevation view of the sealed connector shown in FIG. 4A.

FIGS. 5A and 5B show perspective views of coupling of different components using embedded lateral connectors.

FIGS. 6A-6C show perspective views of PCBs electrically connected using embedded lateral connectors.

### DETAILED DESCRIPTION

This disclosure is directed to printed circuit boards (PCBs) that include one or more embedded lateral connec-

tors, which may be used to couple components to the PCB. The connectors (also referred to as an "interface" or a "coupler") may be formed as apertures configured to receive a plug or other corresponding solid connector (i.e., female connectors), as plugs configured to engage connector receptacles (i.e., male connectors), or a combination of both. Unlike conventional connectors that engage a PCB through a top or bottom surface, the connectors described herein are positioned in the lateral sides of the PCB and thus can project into the PCB on the order of millimeters or centimeters since PCBs have larger width and length than a thickness. Typically, a thickness of a PCB is just a few millimeters in most situations. The connector(s) may be used for data transfer, for supply of power, and/or for other electronic functions

In accordance with one or more embodiments, layers used to form a PCB may be formed with one or more apertures or cutouts on some layers to accommodate placement of the embedded lateral connector(s) between at least some of the layers. The apertures may be formed by die cuts or removing material in other ways (e.g., milling, etc.), formed by printing each layer to exclude material in locations to form the aperture(s), or by other known techniques to form a layer with at least one aperture. A PCB may be formed using the layers. For example, an inner layer may be formed that includes a first planar side and a second planar side opposite the first planar side. A connector may be coupled to the inner layer such that an aperture with a longitudinal axis is oriented parallel with the first planar surface. An opening of the connector may be aligned with a side of the inner layer. The connector may create an electrical connection between the inner layer and contacts included in the connector that are configured to engage a plug. In other embodiments, the connector may be a plug, but may be formed in a similar manner. Next, a set of layers may be coupled to the first planar side of the inner layer and another set of layers may be coupled to the second planar side of the inner layer. The layers may then be adhered (e.g., glued, laminated, cured, etc.) to form a PCB having the connector embedded laterally in the PCB.

The apparatuses and techniques described herein may be implemented in a number of ways. Example implementations are provided below with reference to the following figures.

FIGS. 1A and 1B show a pictorial flow diagram describing an illustrative process to create an electronic device with a printed circuit board (PCB) that includes an embedded lateral connector. The process is illustrated as a collection of blocks in a logical flow graph, which represent a sequence of operations. The order in which the operations are described is not intended to be construed as a limitation, and any number of the described blocks can be combined in any order and/or in parallel to implement the process.

FIG. 1A shows an illustrative process 100. At 102, an inner layer 104 may be formed. The inner layer 104 may include a planar layer 106 having a top planar side and a bottom planar side. The layer may include etched or otherwise formed metallic connections on the top planar side, the bottom planar side, or both. The layers, including the planar layer 104, may be formed of insulator material, such as fiberglass (reinforces epoxy resin), plastic, or other material commonly used to form PCBs, and may include conductive materials, such as copper foil or other metallic foil or material. The planar layer 106 may include an aperture or special feature that accommodates coupling of a connector 108 to the planar layer 106 such that at least part of the connector occupies space within the plane of the planar layer



**106**, which is referred to herein as an aperture or special feature. In some embodiments, the layers may be formed by an additive manufacturing process that utilizes three-dimensional (3D) printing. The additive manufacturing process may omit or refrain from adding material in certain areas to form apertures or special features. In some embodiments, the layers may be machined, die cut, or otherwise processed to remove material to form the apertures or special features. The connector may be coupled to the inner layer such that a longitudinal axis of the connector is oriented parallel with the top planar surface. If the connector includes an aperture, an opening of the connector may be aligned with a side of the inner layer. The connector may create an electrical connection between the inner layer and contacts included in the connector that are configured to engage another connector, such as a plug or complementary recess (if the connector is a plug).

At **110**, additional layers may be formed to create a PCB. Top layers **112** and bottom layers **114** may be created, such as using same or similar techniques used to form the planar layer **106** described above. The layers may include etched or otherwise formed metallic connections on a top side, a bottom side, or both of each layer. In some embodiments, the top layers **112** and bottom layers **114** may be mirrored versions of one another. At least some of the top layers **112** may include first apertures **116** while at least some of the bottom layers **114** may include second apertures **118**, which may be a mirrored version of the first apertures **116**. The first apertures **116** and the second apertures **118** may accommodate the volume of the connector, which may reside in a cavity formed by the apertures after assembly of the layers with the inner layer **104**.

At **120**, the top layers **112**, the inner layer **104** and the bottom layers **114** may be assembled such as by stacking the layers on top of one another. When assembled the first apertures **116** and the second apertures **118** may be in alignment and may accommodate the connector **108**, which may be situated between at least some of the layers and at least partly with the apertures.

At **122**, the layers may be adhered (e.g., glued, laminated, cured, etc.) together to form a PCB **124** that includes an embedded lateral connector **126**.

FIG. **1B** shows additional processes **128** that may be performed on the PCB **124** or with the PCB **124**.

At **130**, conventional components **132** may be coupled to a top surface of the PCB **124**, a bottom surface of the PCB **124**, or both. The conventional components **132** may be coupled by solder, by threaded connectors that extend through apertures that extend through all layers of the PCB **124** in the planar surface of the PCB **124**, and/or by other convention techniques. The components may include capacitors, controllers, resistors, pin connectors, and/or other types of conventional components.

At **134**, a component **136** may be coupled to the embedded lateral connector **126**. The component **136** may include a complementary connector **138** that is complementary to the embedded lateral connector **126** that, when joined or coupled to the embedded lateral connector **126**, creates an electrical connection between the PCB **124** and the component **136**. The component **136** may be a power adapter, another PCB, a display, and/or any other type of electronic component that operates by electrical interaction with the PCB. In some embodiments, the embedded lateral connector **126** may include multiple contacts, such as rings or other types of contacts, which may be designated for electrical transmission of different signals. In various embodiments, multiple embedded lateral connectors may be used to couple

to the component **136**. The multiple embedded lateral connectors may be a same type or may be of different types, which may desirably limit coupling position/orientation with the component **136**.

At **140**, the PCB **124** may be coupled to a housing **142** of an electronic device **144**. The housing **142** may secure the PCB **124**, such as by couplers that engage embedded lateral mounting features in the PCB, which are discussed below.

FIG. **2** is a perspective view of an illustrative PCB **200** that includes a plurality of illustrative embedded lateral connectors **202** on a first lateral side **204**. In some embodiments, the PCB **200** may include additional embedded lateral connectors on one or more different lateral sides, such as a second lateral side **206**, a third lateral side **208**, or a fourth lateral side **210**. The PCB **200** may include a top planar surface **212** and a bottom planar surface **214** opposite the top planar surface **212**. Conventional components **216** may be soldered to the top planar surface **212** or otherwise coupled thereto.

FIG. **3A** shows a cross-sectional top view of the PCB **200** shown in FIG. **2**, showing illustrative details of some embodiments of the embedded lateral connectors. In some embodiments, the cross-sectional top view of the PCB **200** may be a cross-sectional view of an inner layer of the PCB, such as the inner layer **104** discussed with reference to FIG. **1A**.

The PCB **200** may include first connectors **302(1)-302(N)** (N), which may be plugs or other extrusions of a male-type connector. The first connectors may include tip(s) **304** and ring(s) **306**, as well as a sleeve, which may be used for grounding purposes. In some embodiments, the first connectors **302** may include multiple rings, which may be separated by insulators to enable transmission of different signals. The tip(s) **304** and the ring(s) **306** include electrical connectivity to an electrical grid formed in layers in the PCB **200**, as discussed above. The first connectors **302(1)-302(N)** may include electrical connection with different layers of the PCB via a first contact **307(1)** and a second contact **307(2)** shown in Detail A, although more contacts may be used depending on factors such as a number or rings of the first connectors **302(1)-302(N)**. In some embodiments, a first contact **307(1)** may include electrical connection with the inner layer while the second contact **307(2)** may include electrical connection with a different layer, possibly an adjacent later.

The PCB **200** may include second connectors **308(1)-308(M)** (M), which may be apertures or other cavities of a female-type connector. The second connectors **308** may include first contact(s) **310** and second contact(s) **312**, and possibly other contacts, which may engage rings, tips, and/or a sleeve of a corresponding connector (e.g., a plug), which are also shown in Detail B. The first contact(s) **310** and second contact(s) **312** may be formed as biasing devices (e.g., leaf spring, etc.) to enable repetitive interaction with a corresponding connector, which may cause deflection (compression) of a contact when mated with one of the second connectors **308(1)-308(M)**. In some embodiments, the first contact(s) **310** may include electrical connection with the inner layer while the second contact(s) **312** may include electrical connection with a different layer, possibly an adjacent later. The second connectors **308** may include retention features **314**, which may engage the corresponding connector to secure the corresponding connector to one of the second connectors **308**. The contacts **310** and **312** include electrical connectivity to the electrical grid formed in layers in the PCB **200**, as discussed above.



In accordance with some embodiments, the PCB 200 may include mounting features 316, which may be embedded in the lateral side of the PCB. The mounting features 316 may enable coupling the PCB 200 to a housing, frame, mounting bracket, other PCB, or other component. The mounting features 316 may include treads or other features to enable corresponding parts to be securely fastened or coupled to the mounting features, such as screws. Besides threaded features, the mounting features may use a snap fit, magnets, friction fit, or other types of coupling features to secure the mounting features to another part.

FIG. 3B shows a cross-sectional top view of the PCB shown in FIG. 2, showing illustrative details of embedded lateral connectors having retention features.

The PCB 200 may include third connectors 318(1)-318(N), which may be plugs or other extrusions of a male-type connector. The third connectors may include tip(s) 320 and ring(s) 322, as well as a sleeve, which may be used for grounding purposes. At least some of the rings 322 may be formed as biased rings or springs, which may deflect upon entry into a corresponding connector, and then engage a corresponding recess to retain the third connector in the corresponding connector. For example, the third connectors may be similar to "banana plugs". In some embodiments, the third connectors 318 may include multiple rings, which may be separated by insulators to enable transmission of different signals. The tip(s) 320 and the ring(s) 322 include electrical connectivity to an electrical grid formed in layers in the PCB 200, as discussed above.

The PCB 200 may include fourth connectors 324(1)-324(M), which may be apertures or other cavities of a female-type connector. The fourth connectors 324 may include first contact(s) 326 and second contact(s) 328, and possibly other contacts, which may engage rings, tips, and/or a sleeve of a corresponding connector (e.g., a plug). The second contacts 328 may be formed as a recess to act as retention features, which may engage the corresponding biased rings or springs to secure the corresponding connector to one of the fourth connectors 324. The contacts 326 and 328 include electrical connectivity to the electrical grid formed in layers in the PCB 200, as discussed above.

In accordance with some embodiments, the PCB 200 having the third connectors 318, the fourth connectors 324, and/or any other connectors described herein, may include the mounting features 316, which may be embedded in the lateral side of the PCB. The mounting features 316 may enable coupling the PCB 200 to a housing, frame, mounting bracket, other PCB, or other component. The connectors described herein may include any of the contacts 307(1), 307(2), 312, and/or 314 described above with reference to FIG. 3A.

FIG. 3C shows a cross-sectional top view of the PCB shown in FIG. 2, showing illustrative details of some embedded lateral connectors having different retention features.

The PCB 200 may include fifth connectors 330(1)-330(N), which may be plugs or other extrusions of a male-type connector. The fifth connectors may include tip(s) 332 and ring(s) 334, as well as a sleeve, which may be used for grounding purposes. At least some of the rings 334 may include directional barbs or securing features, which may enable entry into a corresponding connector, and then engage a sidewall or corresponding features or recesses to retain the fifth connector in the corresponding connector. In some embodiments, the fifth connectors 330 may include multiple rings, which may be separated by insulators to enable transmission of different signals. The tip(s) 332 and

the ring(s) 334 include electrical connectivity to an electrical grid formed in layers in the PCB 200, as discussed above.

The PCB 200 may include sixth connectors 336(1)-336(M), which may be apertures or other cavities of a female-type connector. The sixth connectors 336 may include first contact(s) 338 and second contact(s) 340, and possibly other contacts, which may engage rings, tips, and/or a sleeve of a corresponding connector (e.g., a plug). The second contacts 340 may include retention features, which may engage corresponding rings features, such as the directional barbs or securing features discussed with relation to the rings 334 to secure the corresponding connector to one of the sixth connectors 336. The contacts 338 and 340 include electrical connectivity to the electrical grid formed in layers in the PCB 200, as discussed above.

In accordance with some embodiments, the PCB 200 having the fifth connectors 330, the sixth connectors 336, and/or any other connectors described herein, may include the mounting features 316, which may be embedded in the lateral side of the PCB. The mounting features 316 may enable coupling the PCB 200 to a housing, frame, mounting bracket, other PCB, or other component. The connectors described herein may include any of the contacts 307(1), 307(2), 312, and/or 314 described above with reference to FIG. 3A.

FIG. 3D is a schematic diagram of a first configuration 342 of a connector 344 that includes a wedge 346 inserted into a tip of the connector 342. A second configuration 348 of the connector 344 shows the wedge 346 pushed into the connector 344 along a seam to expand a diameter 350 of the tip, which flares or expands to secure the connector in a corresponding connector or receptacle, such as the corresponding connector discussed with reference to FIG. 3E, below.

FIG. 3E shows a cross-sectional top view of the PCB shown in FIG. 2, showing illustrative details of some embedded lateral connectors utilizing a wedge retention feature for use with the connector shown in FIG. 3D.

The PCB 200 may include seventh connectors 352(1)-352(M), which may be apertures or other cavities of a female-type connector. The seventh connectors 352 may include first contact(s) 354 and second contact(s) 356, and possibly other contacts, which may engage rings, tips, and/or a sleeve of a corresponding connector, such as the second configuration 348 of the connector 344 that includes the wedge 346 inserted into the seam (as shown in FIG. 3D). The second contacts 356 may be formed as a recess to act as retention features that engage the diameter 350 of the tip, to secure the corresponding connector to one of the seventh connectors 352. The contacts 354 and 356 include electrical connectivity to the electrical grid formed in layers in the PCB 200, as discussed above.

In accordance with some embodiments, the PCB 200 having the seventh connectors 352 and/or any other connectors described herein, may include the mounting features 316, which may be embedded in the lateral side of the PCB. The mounting features 316 may enable coupling the PCB 200 to a housing, frame, mounting bracket, other PCB, or other component. The connectors described herein may include any of the contacts 307(1), 307(2), 312, and/or 314 described above with reference to FIG. 3A.

FIG. 4A is a perspective view of a sealed connector pair 400 that secures a wire 402 to a PCB 404. The sealed connector pair 400 may include a housing 406, which may be coupled to a collar 408. The collar 408 may retain a sleeve 410. The sleeve 410 may retain a gasket 412, among other internal parts shown in FIG. 4B, below. The sealed connector pair 400 may enable connection of the wire 402



to electrical components of the PCB 404, while preventing or reducing exposure by the PCB 404 to environmental conditions, such as dirt, moisture, and/or other contamination.

FIG. 4B is a cross-sectional side elevation view of the sealed connector shown in FIG. 4A. As shown, the wire 402 may engage a connector 414, which may create an electrical connection with a connector 416 via contacts 418. The connector 414 may receive the wire 402 and retain the wire, at least in part by friction, a press fit, and/or by retaining features, such as barbs. The connector 414 may abut a first seal 420 positioned between the connector 414, the sleeve 410, and the housing 406. A second seal 422 may be positioned between the sleeve 410, the wire 402, and the gasket 412. The seals 420 and 422 may prevent or reduce exposure by the connector 416 of the PCB 404 to environmental conditions, such as dirt, moisture, and/or other contamination. Meanwhile, the sleeve 410 may be coupled to the collar 408 by clips, snap features, and/or other features to retain the sleeve, and retain the wire 402 in the connector 416. During use, the wire 402 may be coupled to the connector 414, the sleeve 410, seals 420 and 422, and the gasket 412 to form an assembly. The assembly may then be inserted through the housing 406 and into the connector 416 until the sleeve couples to the collar 408, thereby securing or retaining the wire 402 in the connector 416.

FIGS. 5A and 5B show perspective views of different components coupled to embedded lateral connectors. FIG. 5A shows a PCB 500 that includes embedded lateral connectors 502. For example, the embedded lateral connectors 502 may include a first set of embedded lateral connectors 504 and a second set of embedded lateral connectors 506. In some embodiments, the first set of embedded lateral connectors 504 may be a different type of connector than the second set of embedded lateral connectors 506, such as male-type connectors versus female-type connectors, or selected from any other type of connector described above. FIG. 5A also shows a first component 508 and a second component 510 configured to be coupled to the first set of embedded lateral connectors 504 and the second set of embedded lateral connectors 506, respectively.

FIG. 5B shows the PCB 500 coupled to the first component 508 and the second component 510. The first component 508 is coupled to the first set of embedded lateral connectors 504 while the second component 510 is coupled to the second set of embedded lateral connectors 506.

FIGS. 6A-6C show perspective views of PCBs electrically connected using embedded lateral connectors.

FIG. 6A shows a perspective view of a first assembly 600 of PCBs, including a first PCB 602 and a second PCB 604. The first PCB 602 and the second PCB 604 may include one or more embedded lateral connectors 606, as described above. The first PCB 602 may be electrically connected to the second PCB 604 by coupling first embedded lateral connectors of the first PCB 602 directly to second embedded lateral connectors of the second PCB 604. By connecting PCBs in this manner, the PCBs may exchange information and/or electrical signals and may possibly operate in a similar way as a larger PCB that encompasses all components and circuitry of the first PCB 602 and the second PCB 604. In some embodiments, the embedded lateral connectors may operate as a multi-pin connector to facilitate exchange of different signals between the first and second PCB. Additional PCBs may be connected to additional embedded lateral connectors on the first or second PCB.

FIG. 6B shows a perspective view of a second assembly 608 of PCBs in a stacked configuration, including the first

PCB 602 and the second PCB 604. The first PCB 602 and the second PCB 604 may include one or more embedded lateral connectors 606, as described above. The first PCB 602 may be electrically connected to the second PCB 604 by coupling first embedded lateral connectors of the first PCB 602 to second embedded lateral connectors of the second PCB 604 using an adapter 610. The adapter 610 may include a first adapter end 612 and a second adapter end 614 that each include connectors configured to couple to respective embedded lateral connectors 606 of the first PCB 602 and the second PCB 604, respectively. By connecting PCBs in this manner, the PCBs may exchange information and/or electrical signals and may possibly operate in a similar way as a larger PCB that encompasses all components and circuitry of the first PCB 602 and the second PCB 604. In some embodiments, the embedded lateral connectors may operate as a multi-pin connector to facilitate exchange of different signals between the first and second PCB. Additional PCBs may be connected to additional embedded lateral connectors on the first or second PCB.

FIG. 6C shows a perspective view of a third assembly 616 of PCBs in a stacked and coupled configuration, including the first PCB 602 and the second PCB 604. In various embodiments, the first PCB 602, the second PCB 604, or both may include spacers 618 on the planar surfaces of the PCBs. The spacers 618 may create an offset between adjacent PCBs and/or may couple the PCBs, such as by engaging in corresponding features. The first PCB 602 and the second PCB 604 may include one or more embedded lateral connectors 606, as described above. The first PCB 602 may be electrically connected to the second PCB 604 by coupling first embedded lateral connectors of the first PCB 602 to second embedded lateral connectors of the second PCB 604 using the adapter 610. The adapter 610 may include a first adapter end 612 and a second adapter end 614 that each include connectors configured to couple to respective embedded lateral connectors 606 of the first PCB 602 and the second PCB 604, respectively. By connecting PCBs in this manner, the PCBs may exchange information and/or electrical signals and may possibly operate in a similar way as a larger PCB that encompasses all components and circuitry of the first PCB 602 and the second PCB 604. In some embodiments, the embedded lateral connectors may operate as a multi-pin connector to facilitate exchange of different signals between the first and second PCB. Additional PCBs may be connected to additional embedded lateral connectors on the first or second PCB.

In accordance with various embodiments, an electronic device may include a housing, a PCB, a connector, and a component. The PCB may include a plurality of layers, each layer having a planar side that mates with an adjacent layer of the plurality of layers. The PCB may include a connector embedded between at least some of the layers. The connector may be oriented such that a longitudinal axis of the connector is parallel with the planar side. The connector may be configured to receive a corresponding connector to create an electrical connection to at least some of the plurality of layers via the connector. The component may be coupled to the PCB by the connector.

In various embodiments, the component is a different PCB. The PCB and the different PCB may be arranged in a stacked configuration, possibly using the spaces to create an offset between the PCBs and/or couple the PCBs to one another.

The electronic device may include a power source. The electrical connection may include connection to the power source.



The electronic device may include mounting features coupled to a lateral side of the PCB and at least partly located between at least some of the plurality of layers. The mounting feature may include an aperture and coupling features to facilitate coupling to the housing. For example, screws may retain the PCB to the housing via the mounting features

In some embodiments, the connector includes an aperture, and an opening of the aperture aligns with a lateral side PCB. The connector may be configured to engage a corresponding connector. The aperture may include at least partially concave sidewalls that form recesses to retain a plug. A seal may be positioned adjacent to the opening of the aperture and adjacent to a lateral side of the PCB. The seal may prevent environmental debris from entering an aperture of the connector.

In accordance with one or more embodiments, the connector may include an elongated body that extends outward and beyond a lateral side of the PCB. The elongated portion may include a tip and at least one ring. The PCB may include a second connector embedded between at least some of the layers. The second connector may be oriented such that a longitudinal axis of the second connector is parallel with the planar side. The second connector may be configured to receive a different corresponding connector to create a different electrical connection to at least some of the plurality of layers via the second connector. The first connector may include a different shape than the second connector.

### CONCLUSION

Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described. Rather, the specific features and acts are disclosed as illustrative forms of implementing the claims.

What is claimed is:

1. A method comprising:
  - forming an inner layer of a printed circuit board (PCB) that includes a first planar side and a second planar side opposite the first planar side;
  - coupling a connector to the inner layer, the connector having an elongated body with a longitudinal axis that is oriented parallel with the first planar side, the elongated body extending outward and beyond a lateral side of the PCB;
  - coupling a first set of one or more layers to the first planar side of the inner layer;
  - coupling a second set of one or more layers to the second planar side of the inner layer; and
  - adhering the inner layer to the first set of one or more layers and to the second set of one or more layers to form the PCB having the connector embedded laterally in the PCB, wherein an outermost layer of PCB includes a spacing feature configured to engage an adjacent PCB, the spacing feature to create a predefined gap between the PCB and the adjacent PCB.
2. The method as recited in claim 1, wherein the connector includes one or more contacts that create an electrical connection between the inner layer and the connector, and wherein the one or more contacts are further configured to engage a corresponding connector of a different PCB.
3. The method as recited in claim 1, wherein the elongated body has a first height relative to the first planar side at a first point along the longitudinal axis and a second height relative

to the first planar side that is different than the first height at a second point along the longitudinal axis.

4. The method as recited in claim 1, further comprising connecting the PCB to the adjacent PCB via the connector and a second connector of the adjacent PCB, the second connector being recessed within the PCB.

5. The method as recited in claim 1, wherein the elongated body of the connector includes a tip and at least one ring.

6. The method as recited in claim 1, wherein the inner layer includes a layer aperture configured to receive the connector, and wherein coupling the connector to the inner layer includes coupling the connector to the inner layer within the layer aperture.

7. The method as recited in claim 6, further comprising forming the layer aperture using at least one of a die cutting process or an additive manufacturing process that omits adding material in a location to form the layer aperture.

8. A printed circuit board (PCB) comprising:

- a plurality of layers, at least one layer of the plurality of layers having a planar side that connects to an adjacent layer of the plurality of layers; and
- a connector embedded between at least some layers of the plurality of layers, the connector having an elongated body that extends outward and beyond a lateral side of the PCB, wherein a height of the elongated body relative to the planar side varies along the elongated body.

9. The PCB as recited in claim 8, wherein the connector includes one or more contacts that create an electrical connection between a layer of the plurality of layers and the connector, and wherein the one or more contacts are further configured to engage a corresponding connector of a different PCB.

10. The PCB as recited in claim 8, further comprising a mounting feature coupled to the lateral side of the PCB and at least partly located between at least some layers of the plurality of layers, the mounting feature including an aperture and one or more threads to facilitate mounting the PCB on a housing.

11. The PCB as recited in claim 8, wherein an outermost layer of the plurality of layers includes a spacing feature configured to engage an adjacent PCB, the spacing feature to create a predefined gap between the PCB and the adjacent PCB.

12. The PCB as recited in claim 8, wherein the connector is a first connector, and further comprising a second connector embedded between at least some layers of the plurality of layers, the second connector oriented such that a longitudinal axis of the second connector is parallel with the planar side.

13. The PCB as recited in claim 12, wherein the first connector is a first shape that is different than a second shape of the second connector.

14. An electronic device comprising:

- a housing;
- a printed circuit board (PCB) including:
  - a plurality of layers, at least one layer of the plurality of layers having a planar side that connects to an adjacent layer of the plurality of layers; and
  - a connector embedded between at least some layers of the plurality of layers, the connector having an elongated body that extends outward and beyond a lateral side of the PCB;
- a component coupled to the PCB by the connector; and
- a mounting feature coupled to the lateral side of the PCB and at least partly located between at least two layers of the plurality of layers, the mounting feature including



an aperture and one or more coupling features to facilitate mounting of the PCB on the housing.

**15.** The electronic device as recited in claim **14**, wherein the component is a different PCB.

**16.** The electronic device as recited in claim **14**, wherein the elongated body has a first height relative to the planar side at a first point along a longitudinal axis of the connector and a second, different height relative to the planar side at a second point along the longitudinal axis of the connector.

**17.** The electronic device as recited in claim **14**, wherein the connector includes one or more contacts that create an electrical connection between a layer of the plurality of layers and the connector, the one or more contacts further configured to engage the component.

**18.** The electronic device as recited in claim **17**, further comprising a power source, and wherein the electrical connection includes a connection to the power source.

**19.** The electronic device as recited in claim **14**, wherein the connector is a first connector, and further comprising a second connector embedded between at least some layers of the plurality of layers, the second connector oriented such that a longitudinal axis of the second connector is parallel with the planar side.

**20.** The electronic device as recited in claim **19**, wherein the first connector is a first shape that is different than a second shape of the second connector.

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